Développement de photocatalyseurs à propriétés acido/basiques pour le traitement d'effluents aqueux par photocatalyse sous pression et température

Development of photocatalysts with acid/base properties for the treatment of aqueous effluents by photocatalysis under pressure and temperature

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In most parts of the world, the quality of water has deteriorated considerably since 1990 with organic and chemical pollutions caused mainly by pathogens, pesticides, sediments, heavy metals, plastic and microplastic wastes or persistent organic pollutants (POPs) [1]. In addition, 2.3 billion people, about a third of the planet's inhabitants, still do not have access to reliable sanitation services. The deterioration in water quality has led to new, more restrictive legislations in order to protect water resources. For instance, since January 1st 2018, new regulations have been implemented like for the monitoring of aqueous emissions from ICPEs (installations classified for environmental protection) or the strengthening of existing emission limit values (ELVs) (framework directive on water (2000 / 60 / EC)).

Because of the increase of the pollution and of the new legislations on water quality, new processes for the treatment of water and wastewater have to be developed, either to treat traces of pollutants (pharmaceutical compounds, pesticides, PAHs (polycyclic aromatic hydrocarbons), microorganisms, ...) or to treat industrial waters containing organic compounds refractory to biodegradation [2].

Several processes are currently marketed like oxidizing treatments using H2O2/UV, or O3/UV, chlorination processes or non-destructive treatments such as adsorption on activated carbon. The former solutions are large consumers of H2O2 and O3 and/or a source of by-products such as chloramines while the latter ones only transfer pollution.

On the other hand, catalytic processes, such as photocatalysis (PC) [3] and catalytic wet air oxidation (CWAO) [4] are processes that allow organic matter to be completely oxidized without consuming any oxidant other than oxygen from air. PC works at ambient temperature and atmospheric pressure by activating the catalyst, generally TiO2, under UV while CWAO requires generally high temperatures and pressures (pressures generally greater than 20 bars (typically 50 bars) and temperatures higher than 120 ° C (typically around 200 ° C) but also catalysts containing noble metals such as Pt and Ru deposited on oxide supports (TiO2, ZrO2, CeO2...) or carbon.

Unfortunately, each of these two processes has drawbacks. The photocatalytic process, which uses very little energy, is a relatively slow process addressing effluents with pollutants at low concentration (< ppm) while CWAO is a very energy-intensive process. At IRCELYON, first results coupling photocatalysis and thermal catalysis through the activation of TiO2, one of the most efficient catalysts in PC and one of the supports frequently used in CWAO, are shown to be very interesting while using UV, T° and P conditions less energetic than CWAO

The objective of the PhD will be to develop new catalytic systems for this innovative "thermo-photocatalytic" process activated under temperature, pressure and UV illumination. In particular,

attention will be paid to materials having both interesting photocatalytic properties and excellent acid-base properties to favor adsorption on materials and to avoid polymerization.

The different tasks related to this PhD subject will be the following:

- Elaborate catalytic materials based on the support used in CWAO such as mixed TiO2-ZrO2 or TiO2-Nb2O5 obtained by different methods (hydrothermal treatment, impregnation, coprecipitation...)
- Determine the acid-base properties by calorimetry or FTIR using pyridine or CO2 probes.
- Characterize the optical and physicochemical properties using XRD, RAMAN, MET, MEB, HRTEM, TRMC, UV-Vis, XPS, ...
- Evaluate their efficiency under different conditions of temperature, pressure or UV illumination using model molecules such as phenol
- Establish correlation between treatment efficiency and acid-base, physicochemical and optical properties of materials.

Profile of the candidate

The candidate should have good knowledge in the synthesis of oxide materials and their characterization.

Please send your application with a detailed CV including grading and marks as well as a motivation letter.

References

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[4] Kyoung-Hun Kim, Son-Ki Ihm, Journal of Hazardous Materials 2011, 186, 16-34.